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THESIS

**OPTIMIZING MARINE CORPS PERSONNEL
ASSIGNMENTS USING AN INTEGER PROGRAMMING
MODEL**

by

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**OPTIMIZING MARINE CORPS PERSONNEL ASSIGNMENTS USING AN
INTEGER PROGRAMMING MODEL**

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ABSTRACT

The Marine Corps has long been successful in assigning its available personnel inventory to vacant billets. However, by our research, it has not done so while minimizing the assignment costs faced by the Marine Corps when moving a Marine to another permanent duty station. With increased pressure on cost savings due to shrinking budgets, the importance of cost minimizing efforts is becoming more significant.

This thesis examines the Marine Corps personnel assignment process and proposes a methodology of optimizing the allocation of Marine Corps personnel that minimizes assignment costs, while taking into account constraints such as military occupational specialty, billet vacancies, duty station preference, and seniority. Optimization is achieved by incorporating an integer programming model into the personnel assignment process. The model is tested by contrasting the results of the actual assignments of a 15 Marine sample with the results of simulated optimization assignments of the same sample. The findings of this thesis show that the proposed methodology is both valid and feasible, and could yield significant monetary savings for the Marine Corps.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASR	Authorized Strength Report
BAH	Basic Allowance for Housing
CONUS	Continental United States
DoD	Department of Defense
EFMP	Exceptional Family Member Program
ESGM	Enlisted Staffing Goal Model
HRDP	Human Resource Development Process
IP	Integer Programming Model
LP	Linear Programming Model
M&RA	Manpower and Reserve Affairs
MCO	Marine Corps Order
MCTFS	Marine Corps Total Force Structure
MMEA	Manpower Management Enlisted Assignment
MMOA	Manpower Management Officer Assignment
OCONUS	Outside of the Continental United States
PCA	Permanent Change of Assignment
PCS	Permanent Change of Station
TOS	Time on Station
YCS	Years of Commissioned Service
YOS	Years of Service

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I. INTRODUCTION

The Marine Corps Manpower and Reserve Affairs (M&RA) office has the arduous task of managing the assignment of orders to more than 202,000 active-duty Marines. This task is complicated further with a reduction in budget, resulting in fewer Marines than there are positions to be filled, and a fast-paced operational tempo. So, how does M&RA manage the assignment process? It puts the responsibility on one of over 50 Officer and Enlisted Monitors. The monitors have a complex task in front of them, as they have to consider many attributes (such as ranks and occupational fields) and assign each Marine to a billet while insuring that force readiness is maintained.

The Marine Corps has long been successful in assigning its available personnel inventory to vacant billets; however, by our research, the Marine Corps has not done so while minimizing the personnel assignment cost. With the increased pressure on cost savings due to shrinking DoD budgets, the importance of cost-minimizing efforts is becoming more significant.

This thesis examines the Marine Corps personnel assignment process and proposes a methodology of optimizing the allocation of Marine Corps personnel that minimizes assignment costs, while taking into account constraints such as military occupational specialty, billet vacancies, duty station preference, and seniority. The implementation of the decision-modeling tool proposed in this thesis will enhance the individual monitor's ability to consider the attributes of individual Marines' and the readiness and manpower needs of the Marine Corps, while minimizing the costs associated with the allocation of Marines to billets. This optimal solution will ensure that every Marine has a fair opportunity to get the position he wants, given the constraints.

The Marine Corps is the smallest service in the United States military, with roughly 202,000 Marines on active duty. Though there are small detachments all around the world at which Marines could be stationed, there are 10 major installations where Marines currently serve: Marine Corps Air Ground Combat Center, Twenty-nine Palms, CA; Marine Corps Base Camp Pendleton, CA; Marine Corps Air Station Miramar, San

Diego, CA; Marine Corps Base Kaneohe Bay, HI; Marine Corps Air Station Yuma, AZ; Marine Corps Base Quantico, VA; Marine Corps Base Camp Lejeune, NC; Marine Corps Air Station Cherry Point, NC; Marine Corps Air Station Beaufort, SC; and Marine Corps Bases Japan. Each base serves a different mission and supports different units, however, one thing they all have in common is that each one has Marines transferring in and out on a daily basis. Figure 1 shows the geographic locations of major Marine Corps installations.

This thesis will proceed with a review of the most relevant and current literature on the topic of personnel assignment optimization. It will continue with a description of the methodology used to build the decision modeling tool and an analysis of the results from testing the model with actual personnel assignment data. The conclusion of this thesis will provide some context for the use of the model and recommendations for further research.

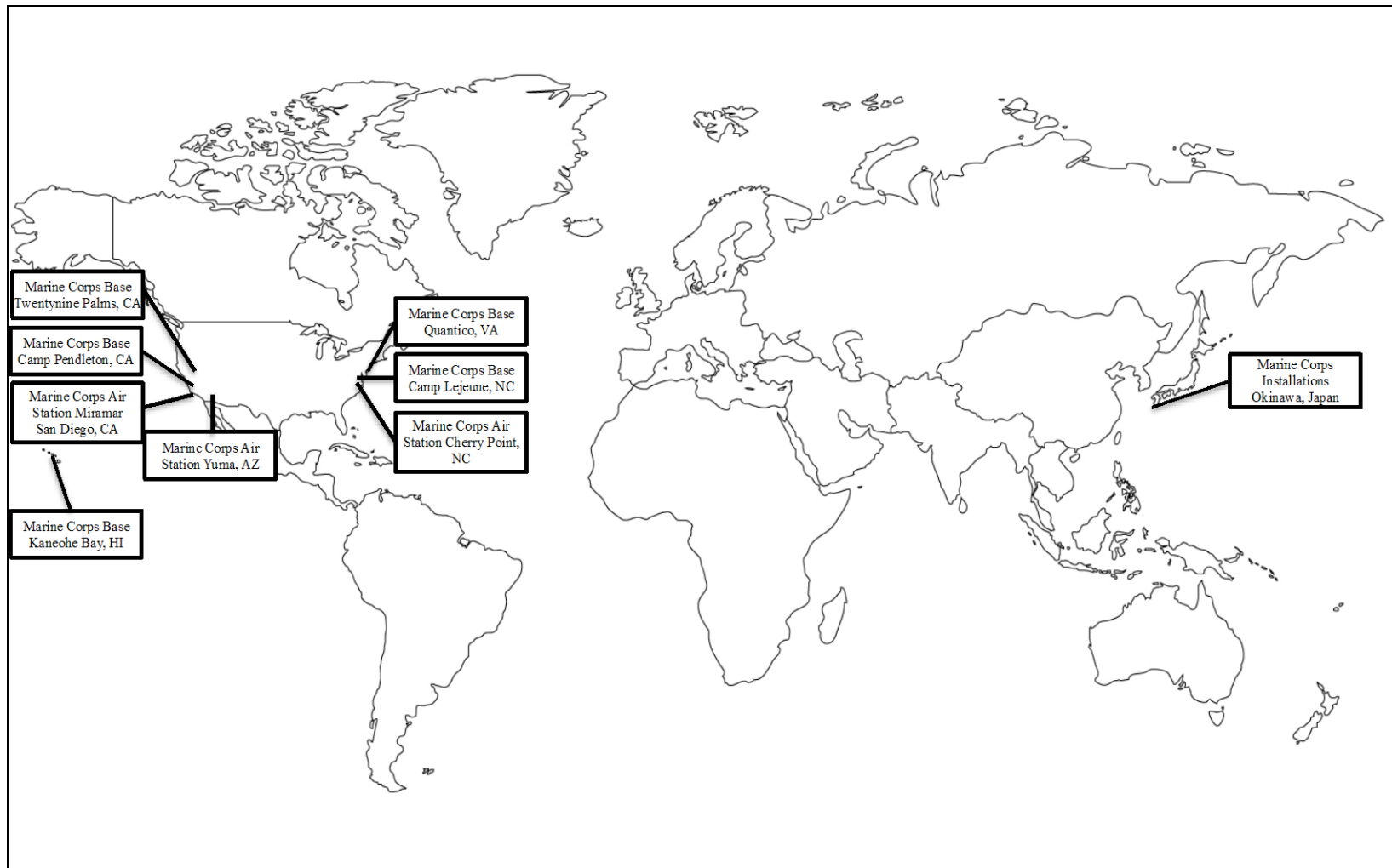


Figure 1. Map of Major Marine Corps Installations

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II. BACKGROUND

A. OVERVIEW

The references that follow are the Marine Corps Orders that guide the personnel assignments process and influence the decisions made by the monitors at M&RA. These orders are the framework of the Marine Corps personnel assignment process.

B. MARINE CORPS ORDERS

1. Marine Corps Order 1300.31A (1992)

Marine Corps Order (MCO) 1300.31A disseminates the Enlisted Classification and Assignment Documents. These documents include the Enlisted Staffing Goal Report (ESGR) that is produced by the ESGM, the ASR, and the Enlisted Personnel Availability Digest (EPAD). Together, these reports provide the information necessary to allow M&RA and the individual monitors to make decisions concerning enlisted personnel assignments.

2. Marine Corps Order P1000.6G (1999)

Marine Corps Order P1000.6G provides guidance on Assignments, Classification, and Travel System Manual for the United States Marine Corps. This order specifically covers the policies for assignments and orders for officers and enlisted personnel, as well as the steps that must be taken during the assignment process. Though the steps outlined are somewhat vague, allowing for flexibility of the specifics within a system as changes may occur, the order does set forth a list of requirements to be met, which were also mentioned in the Ramirez and Park study.

3. Marine Corps Order 5320.12G (2010)

Marine Corps Order 5320.12G prioritizes the allocation of personnel to billets based on the table of organization (T/O). This order provides necessary guidance to M&RA and the monitors during the assignments process.

C. SUMMARY

Monitors use the guidance provided in these orders to execute the Marine Corps personnel assignment policy. Monitors consider the duty station preference of individual Marines, along with other factors such as rank, MOS, and TOS, and attempt to find the billet that best matches the attributes of the Marine. Presently, this is done manually by the monitors, without the aid of a decision modeling tool.

III. LITERATURE REVIEW

A. OVERVIEW

The Marine Corps assignments process has undergone multiple changes over the past two decades. Numerous studies have been conducted to identify deficiencies in the assignments process and to recommend improvements to make it more efficient. However, the common trend of previous studies was to suggest improving the efficiency of the manual match between the attributes of individual Marines and the requirements of given billets, while overlooking the cost of personnel assignment. This thesis develops a computer-based, more efficient optimization model to be used by monitors in the personnel assignment process to not only achieve a quality match between Marines and billets, but to also minimize personnel assignment costs.

Some of the previous studies made recommendations for web-based systems that would assist the Monitors in the assignment process. Though these studies contain very thorough analyses, they differ from the approach taken in this thesis in that they do not look into using a low cost, yet very efficient, decision modeling approach of integer programming as a method of optimizing the personnel assignment process. In addition, previous studies have not considered the benefits of using integer programming as a budgeting tool.

The studies reviewed below provide the requisite background information to understand the Marine Corps personnel assignment process and the changes that have been made over time. The reviewed studies are organized based on the primary area upon which each is focused.

B. ASSIGNMENTS

1. Study by Fecteau (2002)

The 2002 thesis by Ly Fecteau of the Naval Postgraduate School analyzed the processes the Marine Corps uses to get to the assignments process. Fecteau's thesis outlined the entire Human Resources Development Process (HRDP) as well as the

Manpower and Reserve Affairs (M&RA) processes which together determine the number of assignment vacancies, the personnel that will be placed in these assignments, and which assignments will go unfilled. The thesis begins by giving an overview of the Marine Corps uses the Concept Based Requirement Process (CBRP), which determines the Marine Corps capabilities requirements. The next processes covered are the steps M&RA takes to get to two products. The Table of Organization (T/O), the Marine Corps end strength, and Transients, Transfers, Prisoners, and Patients (T2P2) are all inputs required to get the Troop List and the Authorized Strength Report (ASR). These two documents determine what assignments will be filled and what assignments will be left open, giving the monitor's final allocation of assignments. Once these steps were outlined, Fecteau analyzed each one using three methods: systems theory, labor market economics, and job matching theory.

Fecteau determined that the assignment process is inefficient and needs improvement. Recommendations included creating a web-based assignment process that would allow the Marine and the Monitor the ability to interact during the assignments process. With Fecteau's concept of web-based integration, the individual will be responsible for ensuring that his information is current, much of which would be done automatically from one of the multiple systems the Marine Corps already uses such as Marine Online (MOL) and Marine Corps Total Force System (MCTFS). All that would be needed from the Marine would be individual verification of the information prior to the model being run.

Similar to Fecteau's work, this thesis proposes a model that would assist the monitor in determining the optimal assignment solution. However, this thesis goes a bit further by assisting the monitor in the assignment process, while also considering the budgetary constraints inherent to the process.

2. Study by Morgan (2005)

The 2005 thesis by Jerry Morgan of the Naval Postgraduate School analyzes the importance of assignments for officers, Major and below, in the U.S. Marine Corps and how those assignments affect their promotion and retention rates. Using a list of 30

variables, Morgan conducted a regression analysis to determine specific causes and isolate variables that would help to identify the officers most likely to exit the Marine Corps. Specifically, Morgan's thesis attempted to determine whether spending time in the operating forces or in the supporting establishment would have a greater impact on an officer's decision to leave the service and how competitive they would be for promotion.

The author's conclusion was that officers who spent too much time in both their Primary Military Occupational Specialty (PMOS) and the Fleet Marine Force (FMF) increased their chances of leaving the service but it also decreased their chances of promotion. Similarly, the research found that officers who spent too much time out of their PMOS and more time in the supporting establishment also had a high rate of attrition and failure to promotion. The author realized that this study did not reveal any ground breaking evidence that previous studies and the common knowledge of Marine careers would not have predicted. However, he did point out that manpower should be aware of this and assign officers accordingly. The author's recommendation was that further analysis and data collection needed to be done because his analysis was very limited in scope.

This thesis provides good insight into our research due to the authors' use of analysis between retention and assignments. The other information that this research offers us is that the optimal solution may not always be as simple as inputting data and getting a solution that is a perfect situation for all involved. Based on the research Morgan conducted, Marines and Monitors need to look at the assignments and ensure that the solution proposed will meet the needs of the Marine Corps but also the needs of the individual Marine. One variable that will be taken into account is the duty station preference of the Marine, however oversight from the Monitor may be needed to ensure the suitability for that assignment.

Though Morgan's research was on historical data it provides insight into how important the assignment process is and reinforces the need for a model, which achieves an optimal solution while meeting the needs of the Marine Corps.

3. Study by Chatfield and Gullett (1988–1991)

This was a seven-part study conducted at the Navy Personnel Research and Development Center. Robert Chatfield and Stephanie Gullett, researchers at the Navy Personnel Research and Development Center, did an in-depth analysis of the Marine Corps' need for an Officer Assignment Decision Support System (OADSS). Their premise was that the current system was antiquated and manpower intensive, requiring not only more time, but not achieving an optimal solution. The OADSS was developed to aid the monitors in their decision making with regards to assignments, noting four discrepancies in the assignments process; lack of standardization among the strategies monitors use, lack of user friendly procedures for data retrieval, labor-intensive procedures, and inadequate and informal training for monitors.

Though much of what the authors propose in their study is the feasibility and integration of a network that would have by now become a thing of the past, their assessment concerning the assignments process highlights quite a few problems with the method that is used which our thesis will address, specifically the inefficiency that exists within the current system and the lack of standardization.

This study is useful to our research and provides insight into the concepts and methods, which have already been researched, and what changes were made or recommended due to them. The OADSS was not adopted, most likely due to cost and lack of infrastructure, thus many of the inefficiencies still exist and our model will help address those.

4. Study by Tivnan (1998)

This study looked primarily at the manpower process and how the Marine Corps staff its enlisted assignments. Brian Tivnan, a masters student at the Naval Postgraduate School, begins by explaining the modeling that the Marine Corps uses to determine its staffing goals. The author continues that with a better model, the Marine Corps would be able to meet its unmet staffing goals. Tivnan breaks issues affecting the desirability of an assignment into five categories; the billet, the Marine, interaction between the billet and

the Marine, fit of the Marine to the billet, and the fill. Tivnan argues that these are the factors preventing the Marine Corps from achieving its staffing goal.

The author also addresses a modeling tool that was employed at the time, as well as some of the pitfalls that the monitors experienced while using it. The Enlisted Assignment Model (EAM) was a software package designed to optimize the assignments process. Though at the time, monitors were content with the input data, they were not satisfied with the solution that it produced. The source of the inefficiency generated by the EAM decision model was that it tried to solve the entire enlisted assignments process in one solution without considering all the characteristics of the individual Marines that affect the quality of the match between Marines and billets. For example, it did not consider the Marine's current duty station and cost to move them, whether or not they have an exceptional family member that requires care only available at a specific location (giving them a higher priority on location preferences), and, finally, the needs of the Marine Corps. Our thesis proposes a decision model that considers the aforementioned factors, attains a quality match between Marines and billets, and minimizes assignment costs.

5. Study by Koch (1998)

This study analyzed the Enlisted Assignments Model (EAM), which was used by M&RA to select and assign Marines orders based on a certain set of criteria. In this study, Gary Koch, a masters student at the Naval Postgraduate School, did a thorough analysis of how EAM worked then provided his recommendations for improvement.

EAM is no longer used. It took inputs from two primary sources: The Enlisted Staffing Goal Model (ESGM), and the Marine Corps Total Force System (MCTFS), which is where all data on every Marine is stored. EAM referenced these systems to get answers for the variables such as duty station preferences, rank, and time in service. This model was run on a twice-monthly basis, to determine two assignments or what they called "runs." The first run would be an overseas or OCONUS run. In the middle of the month they would conduct a Continental U.S. (CONUS) run and between these two assignments would be generated for Marines that fell within the timeframe that was

allocated. An additional run was capable of being conducted and that was a CONUS to Overseas run, though no information was available concerning the frequency that this was used.

The problem that Koch found with EAM is that someone other than the Monitor was the manager for the model and the two had limited interaction with one another. The reason for this was likely two-fold. First, computers were not as user friendly at the time and this software likely required a high level of experience dealing with code. The second reason is that in the early- to mid-90's computers were not at every desktop; therefore, they ran the model using a large centralized computer. The outcome was that models would be run without input from the monitors. Therefore, a solution would be created. However, the monitor may have already assigned personnel based on the EAM solution. The result is an assignment process with minimal monitor oversight and very little input from individual Marines, which is why EAM is not used today.

This study provides excellent information that applies to our research. EAM was an unsuccessful model that attempted to provide a solution that would be similar to the one that we have created. The largest difference is the size of the population or group that it is solving for and the lack of Monitor input to the variables, which must be accounted for when designing a new system.

6. Study by Walsh and Cheatham (1994)

In this study, Rory Walsh and Ira Cheatham, masters students at the Naval Postgraduate School, developed a personal computer (PC)-based Monitor Assignment Support System (MASS). Similar to the study conducted by Koch, this system was intended to assist Monitors in selecting personnel for specific assignments. Of all of the studies that were reviewed, this is the most thoroughly designed program; however, like the others, it had many drawbacks. MASS was focused only on officers, and was primarily designed to identify shortages at specific assignments and identify officers capable of filling those. While this would be useful, at the time it was designed, the only real improvement that MASS offered over EAM was that it was more user-friendly.

The primary design of MASS was to update an antiquated system for identifying billet vacancies, and assigning personnel to those vacancies. This was done by providing MASS with the ability to conduct queries of Marine Corps databases and find results for a given search criteria. For example, if they wanted to determine the number of billet vacancies for a specific military occupational specialty (MOS), they could, and the system would also be able to generate a recommended pay grade and time on station (TOS). At the same time, the monitor could take this information and do a second search for personnel capable of filling that billet based on the requisite criteria (MOS, pay grade, and TOS). MASS would then produce a list of possible officers “qualified” to fill that position.

The problem with MASS is that it does not take into account the necessary factors to properly assign individuals to each location. When a Monitor has a pool of officers, essentially all the same, and a pool of assignments for which they are all equally qualified, MASS does not decide which officer should be assigned to which location. This is where many monitors either give assignments on a first come first serve basis, tell the pool of officers to figure it out for themselves, or spend hours upon hours trying to determine the ideal combination given the available criteria.

Like the previous studies, our research and model will focus on optimizing this solution. Our model will give the monitor and the Marine being assigned, the ability to provide inputs to ensure that Marines are not only assigned to billets for which they are qualified, but also to positions and geographic locations that balance the desire of the individual with the needs and fiscal constraints of the Marine Corps.

7. Study by Ramirez & Park (2003)

The study by Mark Ramirez and Dong Ho Park, masters students at the Naval Postgraduate School, is an analysis of the Marine Corps enlisted assignment process and the impact that it has on retention. The authors conducted their analysis with data collected from questionnaires that were distributed to focus groups of ten Marines, primarily located in the Southwest region of the United States. In addition to the questionnaires, Ramirez and Park drew much of their data from Fecteau’s study.

Ramirez and Park analyze the enlisted assignment process from a different perspective than the previous works. By looking at it from a retention perspective, they analyzed the individual Marines' satisfaction with the assignments process.

One major issue that the authors identified is the lack of communication between the individual Marine and the Monitor. Though this doesn't have to be direct contact, what were often lacking were the Marine duty station preferences, which according to their survey's was the primary concern of the Marines when deciding whether to remain in the service or get out. The only place that this information is available was through MCTFS and Marine Online (MOL), both of which the monitor would have had to review prior to making an assignment decision. However, at the time of the study, according to the surveys, MOL was not widely used; therefore the assignments were often assigned with little to no input from the Marine.

The second issue that the authors identified with the system the Monitors used was the Monitors assignment process. Monitors had many variables to consider when placing Marines into each assignment:

- The Marine's capabilities/qualifications
- The impact of the assignment on the Marine's career development
- The recommendations of reporting seniors
- The possibility of personal hardship
- The Marine's time on station and obligated service
- The assignment is made without regard to race, creed, or gender

Managing these variables when making assignment decisions is the most challenging and time consuming process for the monitors. This is where our study with the use of an integer program model will not only ease the burden, but also ensure an even distribution among all available assignments.

In their summary, the authors highlight what steps the Marine Corps needs to take in order to solve their assignment solution. They recommended a matching system that would allow the Marines to see the available assignments, then rank them in preference, and have that system assign Marines to positions based on the input they provided.

C. MANPOWER

1. Study by Wheeler (2010)

The 2010 thesis by Michael Wheeler at the Naval Postgraduate School expounded upon an existing model that managed the inventory of Naval Officers between the ranks of O-1 to O-6. His linear optimization program assesses manpower status on a monthly basis using multiple variables to include current inventory, promotions, accessions, transfers and losses. The primary concept behind this linear programming (LP) model is that it is designed to optimize officer placement, ensuring an even distribution of officers among the various duty assignment locations.

The LP model used in the Wheeler thesis is very similar to the model used in the study that was conducted by Tivnan in 1998, in that they were both attempting to optimize manpower assignments to maximize the number of available personnel, track their location, and ensure the billets they are filling are the most important or key billets that need to be filled. This method differs from the method used in this thesis in that we will be using the IP model as a tool the monitors will use to assign Marines based on a set of characteristics (variables) that will be discussed in detail in Chapter III. The use of detailed characteristics to match Marines with specific billets makes the match more efficient.

D. SUMMARY

This chapter examined the studies completed to date that are the most relevant to the topic of optimizing the Marine Corps personnel assignment process. This review is meant to provide the reader with a sufficient level of knowledge to understand the personnel assignment process—in general terms—and to be able to interpret the results of this study.

Chapter Three will discuss the methodology used to construct the IP model.

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IV. METHODOLOGY

A. OVERVIEW

This thesis examines the Marine Corps personnel assignment process and seeks to optimize that process with respect to personnel assignment costs. For the purposes of this thesis, “costs” refer to the monetary expenses incurred by the Marine Corps to move a Marine (and family members, if applicable) to another permanent duty station, and the associated housing allowance that the Marine will rate at the new duty station. Both components of this cost vary based on the rank of the Marine and whether or not he or she has any dependents.

The Marine Corps has long been successful in assigning its available personnel inventory to vacant billets; however, by our research, the Marine Corps has not done so while optimizing cost. With the increased pressure on cost savings due to shrinking DoD budgets, the importance of cost minimizing efforts is becoming more significant. This thesis proposes a methodology of optimally allocating the Marine Corps’ personnel in order to minimize costs, while taking readiness and manpower requirements into account.

The Marine Corps issues Permanent Change of Station (PCS) orders to thousands of Marines each fiscal year. With every Marine being scheduled to execute PCS orders on an average of every three years, the cost incurred by the Marine Corps is substantial and so are the potential savings if costs can be optimized.

The following steps guided this research:

- Conduct a thorough literature review of articles, reports, theses, books, and magazines, pertaining to this subject that serves as a foundation for our research.
- Conduct a review of applicable Marine Corps Orders and Directives pertaining to personnel assignment policies.
- Conduct interviews with key personnel at Marine Corps Manpower Management Enlisted Assignments (MMEA) and Manpower Management Officer Assignments (MMOA) regarding execution of Marine Corps personnel assignment policies.

- Construct a personnel allocation decision tool, specifically an integer programming model that can be used in the Marine Corps personnel assignment process to identify the optimal personnel allocation to minimize costs.
- Conduct multiple simulated personnel assignments with varying parameters using a sample of 15 Marines who have already been assigned using the current process and compare the actual results to those of the simulation, with respect to cost.

B. THE PERSONNEL ASSIGNMENT PROCESS

1. Policy

“The policy of the Marine Corps is to limit the number of PCS moves to those required to achieve/maintain combat readiness or to ensure equitable treatment and career development of individual Marines (Commandant of the Marine Corps, 1994).” The minimum time on station (TOS) requirement for issuance of PCS orders is 36 months. Waivers to the minimum TOS requirement may be issued on a case-by-case basis to ensure that the most qualified Marine fills each vacant billet (Commandant of the Marine Corps, 1994). It is not uncommon for waivers to be granted to Marines with as little as 24 months TOS.

2. Organizational Framework

The Commandant of the Marine Corps delegates his responsibility of assigning qualified Marines to billets across the Marine Corps to the Deputy Commandant for Manpower and Reserve Affairs (DC M&RA). At the strategic level, the Marine Corps personnel assignment process is a function of “manning” and “staffing.” The Marine Corps defines “manning” as the allocation of manpower resources against slated requirements; it defines “staffing” as the process of assigning individuals to organizations and units (Commandant of the Marine Corps, 2010). Manning is the responsibility of the Deputy Commandant for Combat Development and Integration (DC CD&I) and staffing is the responsibility of DC M&RA. *Marine Corps Order 5320.12G, Precedence Levels for Manning and Staffing* (2010) outlines the relationship and specific responsibilities of the DC CD&I and the DC M&RA as follows:

Budgetary reality determines the need to prioritize and allocate the total number of personnel, as stated in end-strength terms (not actual inventory), against requirements (Tables of Organization and Equipment (T/O&E)) stated in the Total Force Structure Management System (TFSMS). This process, known as “manning,” occurs within the Authorized Strength Report (ASR) and is a reflection of how many billets the Marine Corps can afford to buy. The ASR represents an ideal solution and the results of this process are published semiannually for the current year, the execution year, and the following five out-years.

DC M&RA manages the current inventory of Marines, builds plans for the distribution of future inventory, and assigns available, chargeable inventory against billets “bought” in the ASR process (“staffing”). (pg. 2)

The inventory available for staffing is always constrained by many factors such as cyclical recruiting trends, policy, and training shortfalls just to name a few. As a result, most units will not be staffed to their respective T/O&E, forcing the Marine Corps to prioritize the allocation of planned and available inventory against T/O&E requirements. To do so, the Marine Corps sets “unit precedence levels” which serve as staffing goals for the monitors who are charged with executing personnel assignment policy by issuing PCS orders and assigning a Marine to a billet on a unit’s T/O&E. *Marine Corps Order 5320.12G, Precedence Levels for Manning and Staffing* identifies three distinct unit precedence levels:

- Excepted Commands, which are manned and staffed at 100% of chargeable T/O&E by grade and military occupational specialty (MOS). Examples of excepted commands include Marine Expeditionary Unit (MEU) Command Elements, Marine Corps Recruiting Commands, Infantry Battalions, and Special Operations Companies.
- Priority Commands, which are manned at 95% of chargeable T/O&E by grade and MOS and are staffed at 100% of that manning level. Examples of priority commands are all operating forces, formal schools, Headquarters Marine Corps (HQMC) Departments, and Marine Corps Recruit Depots.
- Proportionate Share (Pro Share) Commands, which are units that are not classified as excepted or priority commands. These units will receive “fair share apportioned manning and staffing” and will absorb manning and staffing fluctuations as structure requirements and inventory change. Any unit not specifically classified as either an excepted or priority command by *Marine Corps Order 5320.12G* is considered a pro share command.

LtCol. Jason Merker, Monitor Section Head at MMEA-8 (Enlisted Assignments Branch), expounded: “When a population of Marines is insufficient to meet all staffing requirements, staffing precedence largely determines which commands will have their billets gapped. We will first staff Excepted and deploying OPFOR (Operational Forces) commands, then other OPFOR commands, then Priority, then Pro-Share. MOSs that are short population must be spread thin, with Pro-Share and even Priority Commands going without due to shortages” (LtCol. Jason Merker, personal communication, October 1, 2012).

3. Execution

At the end user level, the assignment process consists of interaction between individual Marines and their respective monitor. Monitors are a part of the personnel structure at both MMEA and MMOA and are responsible for executing the personnel assignment policy guidance published in *Marine Corps Order 5320.12G, Precedence Levels for Manning and Staffing* and *Marine Corps Order P1300.8R, Personnel Assignment Policy*. Each monitor is responsible for the assignment of Marines to one or more occupational fields. For example, the Aviation Ground Company Grade monitor at MMOA is responsible for the assignment of all 2nd Lieutenants through Captains of the following MOSs: 5902, 5910, 5950, 5970, 6002, 6004, 6302, 6502, 6602, 6604, 6802, 7002, 7204, 7208, 7210, and 7220. Individual monitors are responsible for as few as several hundred to as many as several thousand Marines and corresponding billets to which they can be assigned. For the purposes of this thesis, we will refer to this as the monitor’s “population.”

Communication between an individual Marine and his monitor generally happens within one year of the Marine’s scheduled rotation date. According to LtCol. Merker, the primary means of communication “is e-mail and telephone to establish initial communications between the monitors, Marines, and their leadership” (LtCol. J. Merker, personal communication, October 1, 2012). Monitors also meet with Marines in person at the annual MMEA/MMOA “Roadshow.” During the Roadshow, the monitors from MMEA and MMOA in Quantico, VA travel to every Marine Corps installation (both

CONUS and OCONUS) to give an overview brief of the assignment process and to conduct one-on-one meetings with Marines. This is the Marine's chance to discuss his options with the monitor and have a voice in his next assignment.

Following the Roadshow, monitors compile and analyze the data collected on their population (e.g., individual preference, career progression, family situation) and weigh that against the needs of the Marine Corps to develop an optimal assignment solution for the portion of their population due to rotate during the fiscal year. The staffing goal, based on *Marine Corps Order 5320.12G, Precedence Levels for Manning and Staffing*, provides each monitor a target number of personnel, by grade and MOS, to be assigned to each unit.

The PCS budget is a factor. M&RA, Manpower Management Integration and Administration (MMIA) manages PCS costs for the Manpower Management (MM) Division. MMIA issues MMEA a specific number of PCS orders to apply against staffing requirements. "MMEA develops a budget and requests orders, but MMIA manages the budget and directs MMEA the numbers of...orders to issue based on fiscal constraints" (LtCol. J. Merker, personal communication, October 1, 2012). Monitors do not use a cost optimization tool of any type to aid in this decision process, so the total cost incurred by the Marine Corps is certainly not optimized. Developing a tool that would optimize the cost incurred by the Marine Corps would serve two primary purposes:

- Save the Marine Corps millions of dollars each fiscal year in PCS moves and other costs associated with those moves.
- Help monitors develop better PCS budget estimates for out-years. Since rotation dates can be predicted with reasonable accuracy up to three years in advance, an optimization tool would help monitors better formulate budget estimates for those years, resulting in fiscal efficiency gains and freeing up monetary assets which could then be directed elsewhere.

C. DECISION MODELING

1. Mathematical Programming

Mathematical programming is the most popular and widely used decision modeling technique designed to assist decision makers in identifying the optimal choice out of hundreds, or even thousands, of possible decisions and combinations. Surprisingly

enough, mathematical programming has nothing to do with computer software and requires no advanced mathematical ability, using only basic algebra to derive an optimal solution based upon input parameters and constraints. In decision modeling, programming refers to the process of framing a real world problem or scenario in mathematical terms and solving it (Render, Stair, & Balakrishnan, 2003).

2. Linear Programming

Under the umbrella of mathematical programming, linear programming is the most popular and widely used technique to assist in planning and decision-making. The advancement of computers and related technology has played a huge role in the proliferation of linear programming. More often than not, real world linear programming problems are far too complex to be solved by hand, or even with a calculator, in a timely manner. Over the past decade, spreadsheet-based applications such as Microsoft Excel (and its Solver add-in) have become increasingly capable of handling many of the decision modeling techniques and practical scenarios that commonly present themselves in the business and government arenas (Render et al., 2003). The programming model presented in this thesis uses Microsoft Excel as its platform.

a. Background

For more than 50 years, linear programming concepts have been applied to a variety of industries from medical and operations to accounting and agriculture, to name a few. Regardless of the size, complexity, or diversity of the application, all linear programming models are comprised of three distinct steps (Render et al., 2003):

- *Formulation.* Formulation is the process of breaking a scenario down into its component parts and expressing those parts in terms of simple mathematical expressions. The goal of formulation is to ensure that the resulting set of mathematical expressions completely captures all relevant issues related to the original scenario (Render et al., 2003).
- *Solution.* The solution to a linear programming model is derived from solving the mathematical expressions resulting from the formulation process. Solution involves finding values for the variables of the mathematical expressions to identify an optimal solution to the original scenario (Render et al., 2003).

- *Interpretation and What-If Analysis.* In addition to identifying the optimal solution, Microsoft Excel generates a sensitivity analysis. The sensitivity analysis examines how sensitive the optimal solution is to changes in profits, resources, or other input parameters and allows the decision maker to ask “what-if” questions regarding the problem’s solution.

b. Properties

In addition to the steps outlined above, all linear programming models share the following properties:

- *Objective.* All linear programming problems seek to maximize or minimize some quantity, usually profit, cost, or utility. This is known as the objective function of a linear programming model. This objective must be stated clearly and, more importantly, must be defined mathematically within the construct of the model (Render et al., 2003).
- *Constraints.* Linear programming models include constraints, which restrict the degree to which the objective can be pursued (Render et al., 2003). Constraints are a crucial property of linear programming models because they make it necessary to make the trade-offs and sacrifices required to optimize a solution. Without constraints, it would be much easier to arrive at an optimal solution. Constraints are a common property of linear programming models because limited resources are often a fact of life for decision makers. “Linear programming models usually include a set of constraints known as non-negativity constraints. These constraints ensure that the variables in the model take on only nonnegative values. This is logical since negative values of physical quantities are impossible; you simply cannot produce a negative number of chairs or computers (Render et al., 2003).”
- *Alternatives.* There must be viable alternative courses of action from which a choice can be made. Without at least one viable alternative, no decision would be necessary and, thus, there would be no need for a linear programming model (Render et al., 2003). This thesis will examine how the Marine Corps should allocate its personnel resources among various duty stations to optimize cost. In this scenario, the various allocation combinations serve as alternative courses of action.
- *Linear Relationships.* The objective function and constraints of a linear programming model must be expressed in terms of linear equations or inequalities. A linear mathematical relationship is one in which no terms are squared or raised to any higher power. For

example, the equation $8A+2B=20$ is a valid linear function, whereas the equation $8A^2+2B^3=20$ is not linear because the two variables are raised to a higher power. The same holds true for inequalities. The inequality $8A+2B\geq 20$ is a valid linear function, whereas the inequality $8A^2+2B^3\geq 20$ is not linear (Render et al., 2003). Linear programming models can consist of equations, inequalities, or a mixture of the two.

c. Basic Assumptions

For a linear programming model to be effective and produce a valid result, four basic assumptions must be made:

- *Certainty.* “We assume that conditions of certainty exist. That is, numbers used in the objective function and constraints are known with certainty and do not change during the period being studied” (Render et al., 2003).
- *Proportionality.* We assume that proportionality exists in the objective function and constraints. That is, if it takes 5 hours of labor to produce 1 unit of a product, then it will take 50 hours of labor to produce 10 units of the same product (Render et al., 2003).
- *Additivity.* We assume that additivity is present, “meaning that the total of all activities equals the sum of the individual activities. For example, if an objective is to maximize profit = \$8 per unit of first product made plus \$3 per unit of second product made, and if 1 unit of each product is actually produced, the profit contributions of \$8 and \$3 must add up to produce a sum of \$11 (Render et al., 2003).”
- *Divisibility.* We make the assumption that the solution to our linear programming problem need not necessarily be in whole numbers (integers). This assumption is particularly useful in linear programming models that seek to minimize or maximize a monetary value, since that value can be expressed in fractions of a dollar (dollars and cents). If a fraction of a product cannot be produced, then an integer programming problem exists.

3. Integer Programming

Integer programming is the extension of linear programming that solves problems requiring an integer solution. Many problems can only be solved if variables have integer values. When the Marine Corps decides how many Majors it should assign to an infantry

battalion, it can't assign 3.5; it must assign 3, 4, or some other integer amount (Render et al., 2003). The model presented in this thesis will be an integer-programming model.

Two types of integer variables exist in an integer-programming model:

- *General Integer Variables.* “General integer variables are variables that can take on any nonnegative, integer value that satisfies all the constraints in a model (Render et al., 2003).”
- *Binary Variables.* “Binary variables are a special type of integer variable that can only take on either of two values: 0 or 1 (Render et al., 2003).”
- Additionally, integer programming problems are classified into four types:
- *Pure Integer Programming Problems.* In pure integer programming problems, all decision variables must have integer solutions (Render et al., 2003).
- *Mixed Integer Programming Problems.* In mixed integer programming problems, some, but not all, decision variables must have integer solutions (Render et al., 2003).
- *Pure Binary Integer Programming Problems.* In pure binary integer programming problems, all decision variables are binary in nature and must have solution values of 0 or 1 (Render et al., 2003).
- *Mixed Binary Integer Programming Problems.* In mixed binary integer programming problems, some decision variables are binary and other decision variables are either general integer or continuous valued (Render et al., 2003).

D. THE SIMULATIONS

1. Overview

To demonstrate the potential impact that a cost optimization tool could have on the assignment process, an integer programming model will simulate multiple assignment scenarios involving 15 Marine Officers, who have already been slated for future billets and are pending PCS orders.

2. The Model

a. General Information

The model is an integer programming model with an objective function of minimizing cost, subject to the following constraints: rank, time in grade, the Marine's

duty preference, the number of billets available at each command (by rank), and whether or not the Marine has any dependents. Dependent status is not directly incorporated into the model as a constraint; it is only a constraint in the sense that it affects the cost factors associated with moving an individual Marine--a Marine with dependents costs more to move than does a Marine without dependents. MOS is not considered to be a constraint in our model because it is assumed that Marines will only be assigned to billets in an MOS for which they are qualified. Under the current assignment process, the quarterly PCS budget would also be a constraint, but that information was not available to the authors and is, therefore, not included. The lack of budget data will not impair the simulation, or its results, in any way.

As previously stated, “costs” refer to the monetary expenses incurred by the Marine Corps to move a Marine (and dependents, if applicable) to another permanent duty station and the associated housing allowance that the Marine will rate at the new duty station. Both components of this cost vary based on the rank of the Marine and whether or not he/she has any dependents. For example, a Major is allowed to move more household goods (in terms of weight) at government expense than is a Captain. Therefore, it is likely that the Marine Corps will incur greater cost by moving a Major than it will to move a Captain. Whether or not a Marine has dependents also affects costs. A Captain with dependents is allowed to move more household goods at government expense than is a Captain with no dependents. This amount will constitute the moving component of total cost.

Some Marines also rate a monthly housing stipend, known as Basic Allowance for Housing (BAH). The vast majority of Marines in the ranks of Staff Sergeant and above receive BAH. Junior Marines may also rate BAH if they are legally married. BAH rates vary based on rank, whether the Marine is single or married (known as “BAH with dependents” and “BAH without dependents”), and geographic location. Marines who rate BAH may also elect to live in base housing (where available), in which case they receive no BAH (essentially, the Marine Corps withholds the Marine’s BAH to cover the cost of base housing). To properly account for BAH costs to the Marine Corps during a standard tour of duty, our model will use the amount of BAH that a Marine

would rate (based on the factors listed above) during a three year period. This amount will constitute the BAH component of total cost.

b. Specific Information

The model's design layout is based on a modular concept. Each individual Marine to be assigned is entered into the model with his or her name (or other personally identifiable information) across the top and the possible duty assignments for that individual listed in separate columns on the row beneath the name. These are the decision variables.

The far left-hand column contains the constraints. The constraints should be the number of billets available at each duty assignment, the duty preference for the individual Marine, the number of Marines available for assignment (by rank), and time in grade. The model weights duty preference using time in grade. For the purposes of this thesis, the weighted duty preference/time in grade constraint will be referred to as "Duty Station Average" or "DS Average," for brevity. More specifically, each Marine is ranked in terms of time in grade, with the most senior being ranked number one and going down the list from there. Individual Marines would have submitted a list of their duty station preference to their monitor, which he would then enter into the model. The Marine's first choice would be number one, and so on. Assignment preference is then multiplied by that Marine's time in grade ranking (seniority) to produce a weighted DS Average. Collectively, the DS Average is the sum of the values of the duty stations assigned (1–4), divided by the sample size (15). In mathematical terms it would be written as 'A' is equal to the individual assignment and $(A_1 + A_2 + \dots + A_{15}) \div 15 = \text{DS Average}$. Weighting the individual assignment preference, increases the likelihood that more senior Marines are assigned to their preferred duty station, which makes both logical and practical sense.

The DS Average constraint can be adjusted by the monitor to align his assignment philosophy with guidance promulgated through the Marine Corps chain of command. For example, if budgetary constraints are high, perhaps more emphasis should be place on minimizing cost and not necessarily pleasing individual Marines by giving them their number one choice in terms of duty preference if it would be cheaper to assign

them to their third choice. To do this, the monitor simply should adjust the right-hand side of the DS Average constraint to reflect the policy guidance. This makes it simple for the monitor to enter his desired average assignment preference for the population before running the model. In keeping with our example of minimizing cost, if the monitor decides that he wants the individual Marines of his population to, on average, receive their third duty station preference instead of their second, he simply enters a “3” into the right-hand side of the Individual Assignment Preference field and the model will produce a total cost result where members of the population, on average, receive their third choice.

Were budgetary constraints not the driving factor, the monitor could enter a lower value into the right-hand side of the Individual Assignment Preference field—say 1.2—and the model would produce a total cost result where members of the population, on average, receive close to their first choice of duty assignment. The key consideration, however, in lowering the desired value of the DS Average is generally an increase in the total cost to move the population—relaxing the constraint gives the model more flexibility, thereby reducing costs, while tightening the constraint reduces the model’s flexibility, thereby increasing costs.

The consequence of adjusting the DS Average, aside from affecting the total cost to move the population, is the resulting collective level of satisfaction of the individual Marines that make up the population. For example, by relaxing the DS Average constraint, total cost will almost certainly be reduced. However, the level of satisfaction (or happiness) of the population will also be proportionately reduced. Tightening the constraint will increase cost, while also proportionately increasing the satisfaction level of the population. This point should not be taken lightly, as it presents a delicate balance that must be struck by decision-makers at MMEA and MMOA that must be precisely executed by monitors. If individual duty preference is largely ignored, then satisfaction levels will likely fall, which could have a devastating impact on manpower retention; if individual preference is emphasized too much (relative to cost), then costs could skyrocket and a budget crisis could result.

Given all of the constraints, Excel's Solver adjusts the decision variables to minimize costs subject to the given constraints. The objective function of the model is the sum of each individual's cost to move, multiplied by the decision variable assigned. Since we are working with an integer programming model, all decision variables are binary in nature. This means that the duty station to which the individual is to be assigned will receive a value of "1" and every other prospective duty station to which the individual may (but will not) be assigned receiving a "0." In mathematical terms, the objective function would be written as such:

$$\Sigma [(Total \text{ assignment cost for location } 1 * \text{ Binary decision variable}) + (Total \text{ assignment cost for location } 2 * \text{ Binary decision variable}) + \dots + (Total \text{ assignment cost for location } X * \text{ Binary decision variable})]$$

3. The Simulations

A series of simulations will be conducted to assess the impact that the authors' integer programming model could have on the Marine Corps personnel assignment process. The simulations will be conducted as follows:

- Calculate total cost to the Marine Corps, based on data from the actual assignment of the sample of 15 Marine Officers. This cost is calculated per the methodology stated above.
- Enter constraints, cost, and relevant data pertaining to individual Marines of the sample into the integer programming model.
- Use Microsoft Excel's Solver add-in to determine the optimal solution and calculate the total cost to the Marine Corps resulting from the optimal solution, based on the parameters of emphasis for that simulation.
- Compare the cost of the optimal solution identified by the integer programming model to the cost incurred by the Marine Corps from the actual assignment process.

E. CHAPTER SUMMARY

The Marine Corps is meeting its mission of assigning its available personnel inventory to vacant billets, but could do so with greater efficiency by using a cost optimization tool during the personnel assignment process. An integer programming model would be an excellent tool that the Marine Corps could use to help monitors

efficiently allocate personnel resources while minimizing the cost to the Marine Corps. An assignment simulation and results analysis—which will be conducted and discussed in the next chapter—can provide an assessment of the fiscal impact that such a tool could have on the Marine Corps.

V. RESULTS AND ANALYSIS

A. ACTUAL RESULTS OF ASSIGNMENTS OF SAMPLE

First, the results of the actual assignment process were examined. With duty station preferences being ranked 1–4 (1 being their top choice and 4 being the lowest choice), our 15-person sample attained a DS Average of 1.13. Additionally, the estimated cost of moving the sample is \$2,046,278.

From this point forward, models will be analyzed with respect to four criteria; cost minimization, minimum DS Average, a DS Average of 1.3, and maximum DS Average. The Cost Minimization Model will be the lone exception to this method of analysis, as its only objective is to minimize cost and this model does not consider duty station preference. To achieve the lowest or minimum cost, the DS Average must be set to the corresponding number of duty station options; in our sample case, that number is four.

B. COST MINIMIZATION MODEL

The Cost Minimization Model was only concerned with minimizing the total cost, while satisfying all other constraints. The primary constraint was to fill each billet with one of the available Marines, with the objective function being cost minimization. The result was a total cost of \$2,024,672, which was \$21,606 less than the total cost of the actual assignment results; however, the resultant DS Factor increased from 1.13 to 1.8. Table 1 displays the quantified results of the Cost Minimization Model.

	Total Cost	Difference from Actual Cost	Percent Savings	Resultant DS Factor	Difference from Actual DS Factor
Cost Minimization Model	\$2,024,672	-\$21,606	1.06%	1.8	0.67

Table 1. Cost Minimization Model Results

The Cost Minimization Model would be the best choice if cost is the only consideration. In a time when recruiting numbers are high and attrition is low, this may be a feasible method. However, true cost minimization does not take into account the duty station preference of the individual, which is not sound assignment policy most of the time. As was discussed by Morgan (2005), if duty station preference and assignments are not a priority in the assignments process, the resultant effect is a lowered retention rate. This sentiment was echoed in the study by Ramirez and Park (2003) when the authors found that the primary concern of Marines surveyed when deciding whether to remain in service or not was their duty station location. Figure 2 depicts a scaled-down version of the Cost Minimization Model.

2	Decision Variables												
3													
4	Constraints	Capt 1				Major 1							
5		SYSKOM	DISA	P&R	CNO	SYSKOM	DISA	P&R	CNO	LHS	Sign	RHS	Remarks
6	Billets available-SYSKOM	1				1				0	=	8	Can be filled by any rank
7	Billets available-DISA		1				1			1	=	1	Can be filled by any rank
8	Billets available-P&R			1				1		1	=	5	Filled by either Captain or Major
9	Billets available-CNO				1				1	0	=	1	Filled by Captain
10	Captains available for assignment	1	1	1	1					#VALUE!	=	7	
11	Majors available for assignment					1	1	1	1	#REF!	=	8	
12		1	1	1	1					1	=	1	
13						1	1	1	1	#REF!	=	1	
14	Time in Grade (Maj.)					1	1	1	1				
15	Time in Grade (Capt.)	1	1	1	1								
16	Duty Station Preference Assigned	0	4	0	0	#REF!	#REF!	#REF!	#REF!	#REF!	≤	3	Can be adjusted to suit USMC needs
17													
18	Obj. Function: Minimize Cost	121,490	128,606	144,914	144,914	130,375.08	149,539.30	159,258.98	159,258.98			\$287,864.95	Total cost to the government to move service member from Monterey to assigned command/geographic location.
19													
20	Individual Assignment Preference (weighted by Time in Grade rank)	2	4	1	3	1	3	2	4				
21													
22	Decision Variables	0	1	0	0	0	0	1	0			-\$11,976.22	Cost Savings
23													

Figure 2. Example of the Cost Minimization Model

With personnel satisfaction being an important factor, the following models offer a better solution and will take into account cost as well as seniority and duty station preferences.

C. TIME IN GRADE MODEL

The Time in Grade (TIG) model is similar to the models previously mentioned, but goes a step further by taking an individual's seniority and duty station preference into account. Our sample consisted of eight Majors and seven Captains. Within their grade, each individual was given a ranking between 1–8 and 1–7, respectively, with 8 and 7 being the senior and 1 being the junior Marine. This ranking is then used as a “weight” that is applied to their duty station preference, so that those with more seniority, are more likely to be selected for their higher duty station preference; of course all of this can be adjusted based on the desired DS Average output.

Initially, when this “weighted factor” was applied to the duty station preferences, the senior man was ranked 1 and the junior man would be ranked 8 and 7. However, it quickly became apparent that this did not produce the desired effect—producing the opposite, instead. To remedy this problem, the weights were simply reversed so the senior Major is 8, and the junior Major is 1, and likewise for the pool of Captains within the sample. This encourages the model to give preference to more senior individuals when assigning them to a duty station, because the marginal effect of assigning a senior Marine to his last choice of duty station is greater than that of assigning a junior Marine to his last choice.

Running the model with the previous cost and DS Average in place produced the following results: resultant total cost was \$2,034,938, a \$10,266 increase over the cost minimization model. The resultant DS Average was 1.9, an increase of 0.1 over the cost minimization model.

With the DS Average set to 1.0, meaning that the duty station preference is a high priority, the model was unable to find a solution. This would not always be the case. However, with our sample, there were too many individuals that all selected the same location as their first choice of duty station. The lowest possible DS Average that

could be achieved with our sample was 1.13 at a cost of \$2,046,278—the same total cost yielded by the actual assignment of the sample. This shows that the actual assignment process of our sample placed great emphasis on assigning individuals to their desired duty station. In the actual assignment process, only two individuals were assigned to a duty station that was not their first choice and both of those individuals were assigned to their second choice of duty station. The results of the time in grade model prove that, given the constraint of available billets, this was the optimal assignment scenario for minimizing the DS Average and thereby maximizing the satisfaction level of the individual Marines of the sample.

With the DS Average set to 1.13, the total cost was \$2,046,278, which is equal to that of the actual assignment, and greater than the total cost of the cost minimization model, but with a significantly lower DS Average than that model. Table 2 displays the quantified results of various iterations of the Time in Grade Model.

	Total Cost	Difference from Actual Cost	Percent Savings	Resultant DS Factor	Difference from Actual DS Factor
Cost Minimization Model	\$2,024,672	-\$21,606	1.06%	1.8	0.67
TIG Model with minimum DS Factor	\$2,046,278	\$0	0	1.13	0
TIG Model with a DS Factor of 1.13	\$2,046,278	\$0	0	1.13	0
TIG Model with maximum DS Factor	\$2,034,938	-\$11,340	0.55%	2.0	0.87

Table 2. Time in Grade Model Results

The results of this simulation capture the cost of considering a Marine's TIG and duty station preference in the assignments process. Relative to true cost minimization, it would cost the Marine Corps \$21,606 to consider TIG and duty station preference during the assignments process. Relative to the actual results of our sample (which is a more

relevant comparison), it would cost the Marine Corps \$11,340 to consider TIG and duty station preference during the assignments process. Given that \$11,340 is a relatively small amount of money and by electing to not consider TIG and duty station preference, the DS Average would increase considerably (0.87, or 77%), it is reasonable to conclude that, in this scenario, it is worthwhile for the Marine Corps to consider TIG and duty station preference during the assignments process. Figure 3 depicts a scaled-down version of the Time in Grade Model.

2	Decision Variables												
3													
4	Constraints	Capt1				Major1							
5		SYSCOM	DISA	P&R	CNO	SYSCOM	DISA	P&R	CNO	LHS	Sign	RHS	Remarks
6	Billets available-SYSCOM	1				1				1	=	8	Can be filled by any rank
7	Billets available-DISA		1				1			0	=	1	Can be filled by any rank
8	Billets available-P&R			1				1		1	=	5	Filled by either Captain or Major
9	Billets available-CNO				1				1	0	=	1	Filled by Captain
10	Captains available for assignment	1	1	1	1					1	=	7	
11	Majors available for assignment					1	1	1	1	1	=	8	
12		1	1	1	1					1	=	1	
13						1	1	1	1	1	=	1	
14	Time in Grade (Maj.)					6	6	6	6				
15	Time in Grade (Capt.)	5	5	5	5								
16		0	0	1	0	1	0	0	0	0.133333333	≤	1.14	Can be adjusted to suit USMC needs
17													
18	Obj. Function: Minimize Cost	121,490	128,606	144,914	144,914	130,975.08	149,539.30	159,258.98	159,258.98			\$275,888.72	Total cost to the government to move service member from Monterey to assigned command/geographic
19													
20	Individual Assignment Preference (weighted by Time in Grade rank)	10	20	5	15	6	18	12	24				
21													
22	Decision Variables	0	0	1	0	1	0	0	0			\$1,770,369.65	Cost Savings
23													

Figure 3. Example of the Time In Grade Model

D. SAME RANK MODEL

One shortfall of our mixed rank sample was that to reduce the total cost, many of the Captains were assigned to locations that have a higher BAH rate, while Majors were assigned to locations with a lower BAH rates. This can be adjusted by lowering the DS Average and placing more emphasis on duty station preference, vice cost savings. However, the majority of the actual population pools will be comprised of Marines of the same rank, making this issue a moot point. To validate the model's practicality on a more realistic sample, the sample demographics were adjusted so that each member was assumed to be a Captain. To account for TIG, the senior Major was considered the senior Captain, and the individual that was previously the senior Captain became the 9th ranked Captain.

The results of this simulation validated the theory that an integer programming model could be used to reduce cost and optimize assignment solutions. Several variations of this model were used to compare the marginal changes resulting from adjusting the criteria of emphasis. Table 3 displays the quantified results of various iterations of the Same Rank Model.

	Total Cost	Difference from Cost with a DS Factor of 1.13	Percent Savings	Resultant DS Factor	Difference from a DS Factor of 1.13
Cost Minimization	\$1,960,192	-\$10,159	5.16%	2.07	0.94
TIG with minimum DS Factor	\$1,970,351	\$0	0	1.13	0
TIG with a DS Factor of 1.13	\$1,970,351	\$0	0	1.13	0
TIG with maximum DS Factor	\$1,960,192	-\$10,159	5.16%	2.07	0.94

Table 3. Same Rank Model Results

The results of this model were exactly as expected. The minimum attainable DS Average was 1.13. More importantly, personnel who would have previously been assigned to a location merely due to the cost savings (i.e., Majors), were now assigned to different duty stations, providing an optimal solution with respect to total cost. DS Average and total cost cannot be compared to previous versions of the model because, in this scenario, the demographics of the sample have changed (all personnel are assumed to be of the same rank and, therefore, have different associated cost data and TIG ranks). The results of the Same Rank Model with a DS Average of 1.13 were used as the basis for results analysis because the resultant DS Average is equal to the DS Factor attained following the actual assignment of our sample.

E. SUMMARY

The simulation results discussed above show that an integer programming model is a feasible solution for monitors to use in the personnel assignment process. Though, initially it may take more time to input certain data, the outcome is a model that allows the monitor the flexibility to adjust the assignments based on cost or duty station preference. More importantly, once the monitor becomes familiar with the model they will be able to more easily solve the problem of which Marines get to go where.

It is worth mentioning that the cost savings of our simulations are vastly understated, relative to the cost savings were those same simulations to be conducted on an actual population. This is due in large part to the uniqueness of our sample. The individuals of our sample were only able to be assigned to duty stations in the greater Washington, D.C. area and all were departing from the same location. The geographical proximity of these duty stations causes the deviations in the cost data to be very small, resulting in a proportionately small savings in terms of total cost. An actual population would likely have individuals moving to locations on both the east and west coasts of the continental United States, as well as OCONUS, resulting in much greater cost deviations and total cost savings. However, in a larger, more diverse population, savings of 0.5–2% could easily equate to several hundred thousand dollars.

To further prove the savings that could be realized using such a model, the total cost savings attained in our 15-person sample could be applied to a much larger population. According to Marine Corps Concepts and Programs 2011, the total officer and enlisted populations of the Marine Corps are 21,307 and 181,134, respectively (United States Marine Corps, Programs and Resources Department, 2011). Assuming that PCS orders are issued to one-third of those populations each year and applying the \$10,159 in cost savings (from our simulation) per 15 people, an estimated \$45.7 million in annual savings could be attained. This thesis is intended to serve only as proof of concept—in all likelihood, the savings estimate is on the low end of the cost savings that would be realized in a population with individuals moving to and from multiple duty stations and geographic locations.

VI. CONCLUSION AND RECOMMENDATIONS

A. SUMMARY

This thesis proposes incorporating the use of an integer programming decision modeling tool into the Marine Corps personnel assignment process. The model would serve as a tool to assist monitors in identifying the optimal assignment mix for their population, while considering the characteristics of individual Marines, a unique set of constraints, and guidance from their MMEA/MMOA chains of command. The model proposed in this thesis can be used as a cost-reduction and budgeting tool, as it minimizes personnel assignment costs while ensuring the efficient matching of Marines to billets.

Each year, the Marine Corps allocates a substantial amount of its financial resources to personnel assignments—specifically to cover the costs of moving personnel, their families, and their household goods in the execution of PCS orders. Accordingly, this is an opportune area in which monetary savings could be realized by optimizing those personnel assignments in an attempt to minimize the associated cost. As the DoD fiscal environment becomes more austere and budgets become more and more constrained, optimization and efficiency of financial resources will be critical to mission accomplishment for the Marine Corps.

In addition to being a useful cost-reduction tool, this model can also be a useful budgeting tool. Since individual Marines execute PCS orders approximately every three years (on average), each monitor should be able to forecast the approximate number of Marines in his population to whom orders are due, three years out. Based on the same rationale, monitors should also be able to forecast billet vacancies, three years out. Using this information as inputs into the model, a monitor will be able to project, with some accuracy, the approximate cost that is likely to be incurred to issue PCS orders to the eligible Marines of his population during the next fiscal year (and two years thereafter). Obviously, when dealing with large numbers of personnel, situations will arise—health issues, non-retention, TOS extensions, e.g.—that prevent individuals from executing orders in accordance with the projected timeframe and cause even the best estimates to

deviate from the true amount. However, an estimate derived from using the same model that would be used during the actual assignment process and that has already been shown to reduce total costs would not only provide an accurate estimate for budget formulation, but would also provide a relatively lower estimate, freeing up valuable monetary resources which might be of better use elsewhere.

B. USING THE MODEL

1. Model Enhancement

This thesis serves as proof of concept for integrating an integer programming model into the personnel assignment process. The model that we have developed, while effective, is not practical for large-scale implementation and use in its current format. Given the amount of time that would be required to input the necessary data for individuals of a large population (e.g., more than 100 individuals), it would be impractical to use the same version of the model that we have used for our relatively small sample of 15 individuals. In order to fully integrate the model into the assignment process and make it practical for use on large populations and more user-friendly for monitors, it is recommended that the Marine Corps solicit design assistance from a professional business modeling and software design agency. Adding program functionalities such as macros, drop-down menus, and unique subroutines would greatly enhance the capability of the model, as well as its ease of use.

2. Using the Outputs

It should also be noted that the model's outputs for a given assignment scenario should be used as a starting point by monitors and not as a requirement. While the model will optimize cost, given a set of constraints, it is not an intelligent agent. For example, personnel with dependents are generally assigned to duty stations with lower BAH rates, whereas single personnel are assigned to duty stations with higher BAH rates. Since personnel with dependents are entitled to a higher BAH rate than personnel without dependents, it makes sense that the model would assign them as it does to minimize cost.

However, it can be safely said that the Marine Corps does not desire to have certain duty stations comprised completely of single personnel while others are comprised entirely of personnel with dependents.

Other unique situations—a Marine with a dependent enrolled in the Exceptional Family Member Program (EFMP) due to a medical condition, households with two active duty spouses, e.g.—will inevitably arise which will require monitors to assign certain personnel to certain duty stations that are not cost effective, according to the model. In cases such as these, as well as in the example in the preceding paragraph, it is important that monitors bear in mind that the model’s outputs are to be used as a starting point for their assignment of personnel. The model will provide the monitor with the optimal assignment mix, but it is up to the monitor to review each assignment within the context of their entire population and provide a “sanity check” before issuing PCS orders. More often than not, the optimal solution as indicated by the model will not be feasible from the Marine Corps’ perspective. However, by reviewing the model’s outputs and adjusting them where necessary, a monitor can arrive at an assignment mix that satisfies the intent of the Marine Corps and also offers as significant reduction in cost, relative to an assignment process in which no optimization model was used.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

In order to fully integrate this decision modeling tool into the Marine Corps personnel assignment process, other considerations need to be addressed and more fully researched. Some potential topics for future studies are listed below.

- At what cost can this model be enhanced and made to be more user-friendly?
- Can the model be linked to the Marine Corps Total Force System database so that data on individual Marines can be auto-populated into the model?
- How much and what type of training would be required to incorporate an optimization model into the personnel assignment process, and at what cost?

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APPENDIX A: ACTUAL ASSIGNMENT COSTS

	Mileage Cost ¹	Per Diem Cost ¹	Household Goods Cost ²	Dislocation Allowance ¹	BAH (36 months) ³	Total Cost
Captain 1	\$1340.12	\$1937.25	\$40,170	\$2,754.28	\$98,712	\$144,913.65
Captain 2	1,340.44	3,044.25	40,170	2,960.04	90,072	137,586.73
Captain 3	1,340.12	1937.25	40,170	2,960.04	103,464	149,871.41
Captain 4	1,352.22	1,937.25	40,170	2,960.04	77,976	124,395.51
Captain 5	670.06	1,107.00	39,125	2,319.69	84,564	127,785.75
Captain 6	1,352.22	3,044.25	40,170	2,960.04	77,976	125,502.51
Captain 7	1,352.22	4,151.25	40,170	2,960.04	77,976	126,609.51
Major 1	1,352.22	3,597.75	41,912	3,329.11	80,784	130,975.08
Major 2	1,352.22	3,044.25	41,912	3,329.11	80,784	130,421.58
Major 3	1,352.22	3,044.25	41,912	3,329.11	80,784	130,421.58
Major 4	1,340.12	3,597.75	41,912	3,329.11	109,080	159,258.98
Major 5	1,352.22	3,044.25	41,912	3,329.11	80,784	130,421.58
Major 6	676.11	1,107.00	39,822	2,894.47	66,204	110,703.58
Major 7	1,340.12	3,044.25	41,912	3,329.11	109,080	158,705.48
Major 8	1,340.12	3,044.25	41,912	3,329.11	109,080	158,705.48
Total Cost	\$18,852.75	\$40,682.25	\$613,351	\$46,072.41	\$1,327,320	\$2,046,278.37

¹ The Per Diem, Travel, and Transportation Allowance Committee. (2012). Joint Federal Travel Regulations, Volume 1. Uniformed Service Members.

² U.S. Army Military Surface Deployment and Distribution Command. (2012, March 5). SDDC 400NG Rating Tool v3.

³ Defense Travel Management Office. (2011, December). 2012 BAH Rates-with Dependents.
Defense Travel Management Office. (2011, December). 2012 BAH Rates-without Dependents.

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APPENDIX B: COMPONENT COST TABLES

MILEAGE RATES (FY12\$)

<i>Dependent Status</i>	<i>Rate per Mile</i>	<i>To Quantico, VA</i>	<i>To Washington, D.C.</i>	<i>To Fort Meade, MD</i>
With Dependents (two vehicles)	\$0.23	\$1,352.22	\$1,340.12	\$1,340.44
Without Dependents (one vehicle)	0.23	676.11	670.06	670.22

(The Per Diem, Travel, and Transportation Allowance Committee, 2012)

PER DIEM RATES (FY12\$)

<i>Individual Status</i>	<i>Rate per Day</i>
Service Member	\$123
Dependents Age 12 and Older	92.25
Dependents Under Age 12	61.50

(The Per Diem, Travel, and Transportation Allowance Committee, 2012)

MAXIMUM HOUSEHOLD GOODS ALLOWANCE (FY12\$)

<i>Rank, Dependent Status</i>	<i>Maximum Allowable Weight (in pounds)</i>	<i>Estimated Cost</i>
Captain, with Dependents	14,500	\$40,170
Captain, without Dependents	13,000	39,125
Major, with Dependents	17,000	41,912
Major, without Dependents	14,000	39,822

(U.S. Army Military Surface Deployment and Distribution Command, 2012)

DISLOCATION ALLOWANCE (FY12\$)

<i>Grade, Dependent Status</i>	<i>Amount Allowed</i>
O-3, without Dependents	\$2,319.69
O-3, with Dependents	2,754.28
O-3E, without Dependents	2,504.86
O-3E, with Dependents	2,960.04
O-4, without Dependents	2,894.47
O-4, with Dependents	3,329.11

(The Per Diem, Travel, and Transportation Allowance Committee, 2012)

BASIC ALLOWANCE FOR HOUSING FOR 36 MONTHS (FY12\$)

<i>Duty Station Location</i>	<i>O-3, without Depende nts</i>	<i>O-3, with Dependen ts</i>	<i>O-3E, without Dependen ts</i>	<i>O-3E, with Dependen ts</i>	<i>O-4, without Dependen ts</i>	<i>O-4, with Dependen ts</i>
Quantico, VA	\$57,996	\$75,276	\$59,832	\$77,976	\$66,204	\$80,784
Washington, D.C.	84,564	98,712	89,532	103,464	93,312	109,080
Fort Meade, MD	74,412	82,404	79,596	90,072	80,784	99,360

(Defense Travel Management Office, 2011)

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